CLAIMS

1. A metal foil tube characterized by joining or welding a metal foil with a thickness of 10 to 100 μm.

2. A metal foil tube as set forth in claim 1, characterized in that said metal foil is a stainless steel foil, and said stainless steel is one of ferritic stainless steel, martensitic stainless steel, austenitic stainless steel, and precipitation hardened stainless steel.

3. A metal foil tube as set forth in claim 1 or 2, characterized by being joined by electrical resistance welding.

4. A metal foil tube as set forth in claim 3, characterized in that said electrical resistance welding is seam welding.

5. A metal foil tube as set forth in claim 4, characterized in that said seam welding is performed using a pulse power source and setting a ratio of the conduction time and non-conduction time to 1/15 to 1/7.

6. A metal foil tube as set forth in claim 3, characterized in that said electrical resistance welding is mash seam welding.

7. A metal foil tube as set forth in claim 6, characterized in that said mash seam welding is performed using a pulse power source and setting a ratio of the conduction time and non-conduction time to 1/3 to 1/1.

8. A metal foil tube as set forth in any one of claims 1 to 7, characterized in that at least part of the joint surface is a solid phase joint.

9. A metal foil tube as set forth in any one of claims 1 to 8, characterized in that the joint or weld line is arranged in a line or spiral.

10. A metal foil tube as set forth in any one of claims 1 to 9, characterized in that an absolute value of a hardness difference between the joint or weld zone and matrix part is, in terms of Vicker's hardness (Hv), 25% or less of the hardness of the matrix part.

11. A metal foil tube as set forth in any one of claims 1 to 10, characterized by cold working the metal foil tube to reduce its thickness, smooth the joint zone, even out the shape and surface roughness of the joint zone, and work harden the material of at least said joint zone.

12. A metal foil tube as set forth in any of claims 2 to 11, characterized in that said metal foil is a stainless steel foil, and said stainless steel foil is an annealed material of an austenitic stainless steel.

13. A metal foil tube as set forth in any one of claims 1 to 12, characterized in that the Vicker's hardness of the matrix part of said metal foil tube is 180 or less.

14. A metal foil tube as set forth in any one of claims 1 to 12, characterized in that the Vicker's hardness of the matrix part and weld zone of said metal foil tube is 300 to 600.

15. A metal foil tube as set forth in any one of claims 11 to 14, characterized in that a maximum nitrogen concentration of the surface layer of said stainless steel foil is 3 wt% or less.

16. A metal foil tube as set forth in any one of claims 2 to 15, characterized in that said stainless steel foil is a soft austenitic stainless steel containing

C: 0.05 wt% or less,
Si: 0.05 to 3.6 wt%,
Mn: 0.05 to 1.0 wt%,
Cr: 15 to 26 wt%,
Ni: 5 to 25 wt%,
Mo: 2.5 wt% or less,
Cu: 2.5 wt% or less, and
N: 0.06 wt% or less,

and a balance of Fe and unavoidable impurities.

17. A metal foil tube as set forth in any one of claims 2 to 11, characterized in that said stainless

steel foil is a high strength austenitic stainless steel containing

C: 0.05 to 0.2 wt%,
Si: 0.05 to 3.6 wt%,
Mn: 1.0 to 5.0 wt%,
Cr: 15 to 26 wt%,
Ni: 5 to 25 wt%,
Mo: 5.0 wt% or less,
Cu: 4.0 wt% or less,
N: over to 0.06 wt% to 0.4 wt%,

and a balance of Fe and unavoidable impurities.

18. A metal foil tube as set forth in any one of claims 2 to 12, characterized in that said metal foil is a stainless steel as rolled and the weld zone has a martensite phase precipitated at it.

19. A metal foil tube as set forth in any one of claims 1 to 18, characterized in that a foil tube obtained by joining and shaping metal foil is surface hardened at least at one of its outside surface and inside surface by a hard plating layer.

20. A metal foil tube as set forth in claim 19, characterized in that said hard plating layer is mainly comprised of one or more metals of chromium, nickel, cobalt, and palladium.

21. A metal foil tube as set forth in claim 19, characterized in that said hard plating layer is comprised of an Ni-P-based alloy.

22. A metal foil tube as set forth in claim 21, characterized in that said hard plating layer is comprised of an Ni-P alloy containing, by weight ratio, 1 to 14% of P.

23. A metal foil tube as set forth in any one of claims 1 to 22, characterized in that a vicinity of the joint zone of at least one of the two surfaces of the stainless steel foil is plated with a Group X to XI element or an alloy including such an element or a metal having a melting point of 1200°C or less and then the foil

is resistance welded.

24. A metal foil tube as set forth in any one of claims 1 to 18, characterized in that a metal foil tube obtained by joining or further shaping a stainless steel foil is heat treated at a temperature of 800 to 1100°C.

25. A metal foil tube as set forth in any one of claims 1 to 18, characterized in that a metal foil tube obtained by joining or further shaping a stainless steel foil is heat treated at a temperature of 800 to 1100°C, then the foil tube is hard plated at least at one of the inside and outside surface.

26. A metal foil tube as set forth in any one of claims 1 to 25, characterized in that a weld zone of said metal foil tube has continuous nuggets along the weld line or discontinuous nuggets present at least at 50% or more of the weld line.

27. A metal foil tube as set forth in any one of claims 1 to 26, characterized in that the overlap (x) μm of the joint zone of said metal foil tube satisfies $x \leq 40+5t$ with respect to the metal foil thickness (t) μm.

28. A metal foil tube as set forth in any one of claims 1 to 27, characterized in that the ratio of the inside diameter of said metal foil tube to the thickness of the tube is 1/500 or less.

29. A metal foil tube as set forth in any one of claims 1 to 28, characterized in that a surface roughness Rz of said metal foil tube defined by JIS B0601-2001 is 2.0 μm or less.

30. A metal foil tube as set forth in any one of claims 1 to 29, characterized in that said metal foil tube has a durability of 1×10^6 cycles or more in a fatigue test giving a strain of 0.2% or less at repeated cycles of 60 cycles/min or more.

31. A metal foil tube as set forth in any one of claims 1 to 30, characterized in that it is used for a toner roll and/or development roll of an image forming

device.

32. A method of production of a metal foil tube characterized by comprising a shaping step of shaping a metal foil sheet with a thickness of 10 to 100 μm so that its facing sides overlap and a welding step of welding the overlapped facing sides.

33. A method of production of a metal foil tube as set forth in claim 32, characterized by further having a finishing step of finishing said welded part smooth.

34. A method of production of a metal foil tube as set forth in claim 32 or 33, characterized in that said shaping step has a positioning step of positioning said metal foil sheet at a shaping use core rod before overlapping the facing sides of said metal foil sheet.

35. A method of production of a metal foil tube as set forth in claim 34, characterized in that said positioning step holds the metal foil sheet at a shaping device approaching and moving away from said core rod while constantly maintaining a parallel position with it, bringing said shaping device close to said core rod, and, when the metal foil sheet and core rod come into line contact, pressing and positioning said metal foil sheet with respect to the core rod.

36. A method of production of a metal foil tube as set forth in claim 34 or 35, characterized in that said shaping step has, after said positioning step, a wrapping step of bringing said shaping device closer to the core rod, holding said metal foil sheet between the semicircular cross-sectional recess formed at said shaping device and said core rod, and wrapping said metal foil sheet around the core rod.

37. A method of production of a metal foil tube as set forth in claim 36, characterized in that after said wrapping step, said shaping step has an overlap adjusting step of adjusting the overlap by making part of the circumference of said metal foil sheet displace in the radial direction.

38. A method of production of a metal foil tube as set forth in claim 36 or 37, characterized in that said overlap (x) μm satisfies $x \leq 40+5t$ with respect to said thickness (t) μm.

39. A method of production of a metal foil tube as set forth in claim 32 or 33, characterized in that said welding step is electrical resistance welding.

40. A method of production of a metal foil tube as set forth in claim 39, characterized in that said electrical resistance welding is seam welding or mash seam welding.

41. A method of production of a metal foil tube as set forth in claim 40, characterized in that said electrical resistance welding uses a pulse power source and sets the ratio of the conduction time and non-conduction time to 1/15 to 1/7 for seam welding or uses a pulse power source and sets the ratio of the conduction time and non-conduction time to 1/3 to 1/1 for mash seam welding.

42. A method of production of a metal foil tube as set forth in any one of claims 32, 33, and 39 to 41, characterized in that said welding step is performed by running a current between a conductive stationary electrode member provided in a groove formed along the axial direction of the outside surface of said core rod and a conductive movable electrode member provided facing said stationary electrode member.

43. A method of production of a metal foil tube as set forth in claim 42, characterized in that said stationary electrode member is formed so that part or all of the outside surface is flat.

44. A method of production of a metal foil tube as set forth in claim 42 or 43, characterized in that said stationary electrode member and/or movable electrode member is comprised at least partially of molybdenum or alumina-dispersed copper alloy.

45. A method of production of a metal foil tube as

set forth in any one of claims 42 to 44, characterized in that the hardness of said stationary electrode member and/or movable electrode member and the hardness of said metal foil sheet are substantially the same.

46. A method of production of a metal foil tube as set forth in any one of claims 34 to 36 and 42, characterized in that said metal foil tube is designed to be separated and removed from said core rod by ejecting a fluid from the inside of said core rod toward the radial direction.

47. A method of production of a metal foil tube as set forth in any one of claims 34 to 37 and 42, characterized in that said core rod is comprised of a plurality of members and part is moved in the axial direction to separate the metal foil tube from said core rod.

48. A method of production of a metal foil tube as set forth in any one of claims 32 to 47, characterized in that a ratio of the inside diameter of the metal foil tube to the thickness of said metal foil sheet is 1/500 or less.

49. A method of production of a metal foil tube as set forth in any one of claims 32 to 48, characterized by inserting a metal core into the metal foil tube and cold working the tube by sedging, split roller rolling method, drawing, spinning, or a combination of these methods to reduce the thickness, smooth said weld zone to even out the shape and surface roughness of the weld zone, and work harden the material of the weld zone.

50. A method of production of a metal foil tube as set forth in any one of claims 32 to 49, characterized by plating the vicinity of the joint zone of at least one of the two surfaces of the stainless steel foil by a Group X to XI element or an alloy containing that element or a metal with a melting point of 1200°C or less and then resistance welding the foil.

51. A method of production of a metal foil tube as

set forth in any one of claims 32 to 50, characterized by heat treating a metal foil tube obtained by joining or further shaping stainless steel foil at a temperature of 800 to 1100°C.

52. A method of production of a metal foil tube as set forth in any one of claims 32 to 51, characterized by heat treating a metal foil tube obtained by joining or further shaping stainless steel foil at a temperature of 800 to 1100°C, then hard plating at least one of the inside and outside surfaces of the metal foil tube.

53. A method of production of a metal foil tube as set forth in claim 50 or 52, characterized in that the composition of said hard plating is an Ni-P alloy containing, by weight ratio, 1 to 14% of P.

54. A method of production of a metal foil tube as set forth in any one of claims 32 to 53, characterized in that due to the welding of said metal foil tube, said weld zone has continuous nuggets along the weld line or discontinuous nuggets along 50% or more of the weld line.

55. A production apparatus of a metal foil tube, characterized by having a shaping unit for shaping a 10 to 100 μm thick metal foil sheet to a predetermined shape and a welding unit for welding facing sides of said metal foil sheet.

56. A production apparatus of a metal foil tube as set forth in claim 55, characterized in that said the shaping unit has a core rod of a circular cross-section perpendicular to the axis, a shaping device provided to be able to approach and move away from said core rod and holding the metal foil sheet, and a positioning member for making said shaping device approach said core rod and pressing against said metal foil sheet to position it with respect to said core rod at the time when the metal foil sheet and core rod come into line contact, and

making said shaping device move so as to make said positioned metal foil sheet approach the core

rod and wrap the metal foil sheet in a U-shape around the core rod.

57. A production apparatus of a metal foil tube as set forth in claim 56, characterized in that said shaping device has a holding plate provided so as to approach and move away from said core rod while constantly maintaining a parallel position with it and having a semicircular cross-section recess for wrapping said metal foil sheet in a U-shape with said core rod, a first pressing member for pressing one side of said U-shaped metal foil sheet so as to closely contact the circumference of said core rod, and a second pressing member for pressing the other side of said U-shaped metal foil sheet toward the circumference of said core rod, and

after said wrapping, overlapping the facing side edges of said metal foil sheet to form an overlap part.

58. A production apparatus of a metal foil tube as set forth in claim 56 or 57, characterized in that said the shaping unit has an overlap adjusting means for displacing part of the circumference of said metal foil sheet in the radial direction so that the overlap of the overlap part of the facing sides becomes a predetermined value before the end of the pressing action by said second pressing member.

59. A production apparatus of a metal foil tube as set forth in claim 58, characterized in that said overlap adjusting means is comprised of offsetting devices provided at the inside of said core rod.

60. A production apparatus of a metal foil tube as set forth in claim 58, characterized in that said the overlap adjusting means is comprised of offsetting devices provided at the outside of said core rod.

61. A production apparatus of a metal foil tube as set forth in claim 58, characterized in that said the overlap adjusting means is designed to press a non-contact part where said metal foil sheet does not closely

contact said core rod by a pressing member.

62. A production apparatus of a metal foil tube as set forth in claim 58, characterized in that said the overlap adjusting means is designed to press a pressing member provided at the outside of said core rod into a recess formed in said core rod.

63. A production apparatus of a metal foil tube as set forth in claim 61 or 62, characterized in that said pressing member is any of a cam, roll, tube, or rod-shaped member and is provided to operate separately at each of the two ends in the axial direction of said core rod.

64. A production apparatus of a metal foil tube as set forth in claim 57 or 58, characterized in that said the overlap (x) μm satisfies $x \leq 40+5t$ with respect to said thickness (t) μm.

65. A production apparatus of a metal foil tube as set forth in claim 55, characterized in that said welding unit is an electrical resistance welding unit.

66. A production apparatus of a metal foil tube as set forth in claim 55, characterized in that said welding unit is comprised of a conductive stationary electrode member provided along the axial direction of the outside surface of said core rod and a movable electrode member provided facing said stationary electrode member, grips said overlap part of said metal foil sheet between the two electrode members, and welds it in that state.

67. A production apparatus of a metal foil tube as set forth in claim 66, characterized in that said stationary electrode member is formed so that part or all of its outside surface is flat.

68. A production apparatus of a metal foil tube as set forth in claim 66, characterized in that said movable electrode member is an electrode ring pressing against said overlap part and carrying a current.

69. A production apparatus of a metal foil tube as set forth in any one of claims 66 to 68, characterized in

that said stationary electrode member and/or movable electrode member is comprised at least partially of molybdenum or an alumina-dispersed copper alloy.

70. A production apparatus of a metal foil tube as set forth in any one of claims 66 to 68, characterized in that a hardness of said stationary electrode member and/or movable electrode member and a hardness of said metal foil sheet are substantially the same.

71. A production apparatus of a metal foil tube as set forth in any one of claims 56, 57, or 66, characterized in that said metal foil tube is designed to be separated and removed from said core rod by ejecting a fluid from the inside of said core rod toward the radial direction.

72. A production apparatus of a metal foil tube as set forth in any one of claims 56, 57, or 66, characterized in that said core rod has a fluid passage for ejecting a fluid for separating the welded metal foil tube from said core rod.

73. A production apparatus of a metal foil tube as set forth in any one of claims 56, 57, or 66, characterized in that said core rod has grooves at its outer circumference for preventing said metal foil sheet from closely contacting the core rod.

74. A production apparatus of a metal foil tube as set forth in any one of claims 56, 57, or 66, characterized in that said core rod is comprised of a plurality of members and part is made to move in the axial direction so as to separate the metal foil tube from said core rod.

75. A production apparatus of a metal foil tube as set forth in any one of claims 55 to 74, characterized in that a ratio of an inside diameter of the metal foil tube to a thickness of said metal foil sheet is designed to be 1/500 or less.

76. A metal foil tube characterized by being obtained using a method of production of the metal foil

tube as set forth in claims 32 to 54 or a production apparatus of a metal foil tube as set forth in claims 55 to 75.